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ENHANCING TOLERANCE TO ACCELERATION ($+G_z$) STRESS: THE "HOOK" MANEUVER

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Anti-G straining maneuvers (AGSM) have been utilized by aircrew to enhance tolerance to $+G_z$ stress and reduce the potential for $+G_z$- induced loss of consciousness (G-LOC). Based on many years of teaching individuals to perform an optimum AGSM, one particular technique has proven to be especially useful. This technique is referred to as the "Hook" maneuver. We strongly prefer not giving a particular name (such as M-1 or L-1) to the AGSM when training aircrew. The "Hook" maneuver simply emphasizes the proper mechanics for physiologic enhancement of tolerance. Experience with training a large number of tactical aircrew on the centrifuge has proven the "Hook" maneuver to be an extremely effective teaching tool which is easily understood, rapidly mastered, and easily remembered. A description of the "Hook" maneuver has been requested by many interested groups and is described in this manuscript. It should be emphasized that the optimum AGSM for an individual aviator in a given aerial combat situation is the one that is most effective for him in that situation.

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CONTENTS

FIGURES

TABLES

INTRODUCTION

Anti-G straining maneuvers (AGSM) have been known to enhance $+G_z$-level tolerance for at least 50 years. During World War II a specific technique developed by the scientists at the Mayo Clinic involved simply yelling during exposure to $+G_z$ to reduce visual loss (blackout). Straining maneuvers involving forced expiration against a partially closed glottis became known as M-1 (and M-2) AGSM's. The importance of concurrent tensing of the skeletal muscles was considered an important part of these AGSM's. Many considered the excessive noise (reduced ability to communicate) and throat irritation to be undesirable aspects of the M-1 AGSM Leverett and co-workers suggested modifying the M-1 to reduce these undesired aspects without altering its protective value. The L-1 AGSM was developed requiring complete closure of the glottis along with concurrent skeletal muscle tensing This L-1 technique was shown to be equally, if not more, effective than the M-1. The only drawback was the problem with some individuals holding the pressure (closed glottis) for an excessively long time. Holding a very-high intrathoracic pressure for 7 to 10 seconds, even with concurrent skeletal muscle tensing, can markedly reduce return of venous blood to the heart. This can result in loss of consciousness, similar to that which results when performing a sustained Valsalva maneuver (no concurrent skeletal muscle tensing). Complete closure of the glottis not to exceed 5 seconds was considered the upper limit of maintaining increased chest pressure. Many aviators were taught the M-1 AGSM and effectively utilized it. There is evidence that shows maximum intrathoracic pressure is developed with complete closure of the glottis (L-1). For this reason, along with the reduced noise and throat irritation, we have consistently recommended the L-1 maneuver instead of the M-1 maneuver. The tradition of the M-1, however, dies hard when recommended by veteran aviators and instructors. In fact, we believe that even bringing up the M-1/L-1 terminology for performing an AGSM is counterproductive. We prefer the general terminology, simply teaching that an AGSM can increase $+G_z$ level tolerance if performed correctly. Most aircrew that we have observed actually perform something of a hybrid M-1/L-1. The hybrid AGSM generally begins with an L-1 and ends with an M-1. It is usually very effective. Most importantly, aviators should perform what is most effective for them individually in

a given circumstance. This includes not only effectively increasing blood pressure to ensure adequate blood flow to the central nervous system, but also involves maximum energy conservation to reduce overall fatigue.

For aviators who are uninitiated or unsure of how to perform a proficient AGSM, we have found that instead of insisting on specifically naming the AGSM as an M-1 or L-1, it is advantageous to concentrate on the mechanics of the AGSM. To this end, we teach the "Hook" maneuver. This is not to give the AGSM a specific name, it is just a method to show the aviator how to perform it. Optimally, it is an L-1 maneuver (with the glottis completely closed). The mechanics of the "Hook" maneuver are taught as described in the next section, with constant emphasis on energy conservation and using the appropriate AGSM technique for the specific aerial combat situation.

THE "HOOK" MANEUVER

There are two components to the recommended AGSM. The first component is a continuous and maximum contraction (if necessary) of all skeletal muscles. This includes the arms, legs, chest, and abdominal muscles (and any other muscles if possible). Tensing of the skeletal muscles reduces the pooling of blood in the $+G_z$ dependent areas of the body (especially the abdomen and legs), retaining or returning the blood to the central circulation and therefore to the heart and subsequently the brain. Tensing the skeletal muscles inherently raises the blood pressure also. The second component of the AGSM is the respiratory component. It is repeatedly performed at 2.5 to 3.0 second cycles. The purpose of the respiratory component is to increase the intrathoracic (chest) pressure as shown in Figure 1. Increased chest pressure in the lungs is transmitted to the heart and large arteries in the chest, which in turn increases the driving pressure and blood flow to the brain against the downward $+G_z$ force. The optimum generation of increased chest pressure is achieved by completely closing the glottis. As shown in Figure 2, the respiratory tract is an open system for breathing starting at the nose

and mouth and ending deep in the lungs. The respiratory tract can be completely closed off at several different points. It can be closed off at the lips, at the nose, or with the tongue at the back of the mouth/throat. The most effective way, however, is to close it off at the glottis. The glottis is located behind the "Adams apple" in the throat. You can find it and close it off by saying the word "Hook" with your mouth open. Say the word "Hook" and catch it about 3/4 of the way through the word . . . "Hooo". This should be said following a deep inspiration and forcefully closing the glottis as you say "HOOK". Bear down maximally for 2.5 to 3.0 seconds. Then rapidly and forcefully exhale by finishing the word Hook . . . "ka". This is followed immediately by the next deep inhalation and again saying "Hook" catching it about 3/4 of the way through the word . . . "Hooo". The exhalation and inhalation phase should last no more than 0.5 to 1.0 seconds. The chest pressure falls dramatically during the 0.5 to 1.0 second exhalation and inhalation phase. This sequence is outlined in Table 1 and Figure 3. It is important that it not be held too long since driving pressure and blood flow to the brain are markedly reduced during this phase. It is, however, during this phase that blood flow rapidly returns into the chest and heart. This is aided by the maximally tensed skeletal muscles and the anti-G suit. The blood is then rapidly ejected on the next increased chest pressure cycle. Overall, this is analogous to giving oneself cardiopulmonary resuscitation (CPR). Don't forget not to hold your respiratory straining too long (5 seconds or more) since this prevents return of blood to the heart. It starves the pump and may result in loss of consciousness as illustrated in Figure 4.

It is important to anticipate a rapid-onset, high $+G_z$ exposure whenever possible. The skeletal muscles should be tensed <u>prior</u> to the onset of $+G_z$ with the deep inspiration and "Hook" initiated instantly as the $+G_z$ begins (not too early and not too late). Too early without $+G_z$-stress can be disadvantageous since it may inhibit the protective cardiovascular reflex responses. Too late and it may be difficult (or impossible) to get a full, deep initial inspiration. Getting behind in initiating the AGSM is a difficult, if not impossible situation to make-up without reducing the $+G_z$-stress. The overall sequence is shown in Figure 3 and is continued throughout the $+G_z$ exposure, stopping only when return to a very

low $+G_z$-level is achieved. Don't stop too early.

Only the physical exertion necessary should be expended. Remember always conserve energy, for the next maneuver, engagement, or sortie. This requires a thorough knowledge of your own individual tolerance which may vary from day to day. Additional factors include the optimum snug fit of the anti-G suit which will assist in performing the most effective muscular tensing. Make sure your G-suit is properly plugged into the rapidly responding anti-G valve. Push the press-to-test! Adequate muscular warm-up of your muscles prior to performing a maximum AGSM will ensure optimal muscular tensing. (Don't forget your neck muscles, including range of motion and flexibility of neck movement.) Finally, don't forget to accomplish some low level (approximately $+3G_z$ in tactical aircraft equipped with anti-G suits) G-awareness turns (lasting approximately 10 seconds) prior to requiring an all-out rapid-onset, sustained high G maneuver. The G-awareness turns ensure the anti-G suit is comfortable and functioning properly, your muscles are warmed-up, and your cardiovascular reflexes are mobilized. If you have any symptoms (grayout or blackout) at this low level of $+G_z$-stress analyze the reasons why. If they are correctable, great. If not, the better part of valor may be to return to base without pushing the $+G_z$ envelope on a particular day. Everyone's tolerance can vary and on a given day they can dip to a dangerous low level, increasing the risk for G-LOC. This may be especially true if you are not fully acclimated to $+G_z$ following a long layoff from flying or participating in flights involving some $+G_z$-maneuvering. Analyze the muscles you utilize in your own AGSM. Integrate your physical conditioning program to achieve maximum strength and endurance in those muscle groups. In closing, if you need a maximal AGSM or a rapid-onset, high G maneuver to defeat an enemy or missile, pull out that well polished "Hook" maneuver you have in your hip pocket. It should be second nature and performed automatically without even thinking. Just say "Hook!"

It should be emphasized that every aviator has his own technique for performing his optimal AGSM. The one that gives him the best protection while he accomplishes his mission is the right one. The

"Hook" maneuver is extremely effective and can allow many individuals to successfully achieve $+10G_z$ to $+12G_z$ for 15 to 20 seconds, levels you will hopefully never need. If you have trouble or are in doubt ask for assistance. Your aerospace physiologist or flight surgeon are all willing to help. Alternate maneuvers can be very effective in certain individuals. If you are unsure sign-up for centrifuge training, which will provide a safe environment to perfect your own technique so you will maximally and safely utilize your weapon system to its full capability.

CONCLUSION

In closing, we are not trying to indicate that the method we describe is the only effective way to perform an AGSM. Some aviators may prefer other techniques. The traditional M-1 and L-1 AGSM or variations such as the Chinese "Q-G" maneuver may be the preferred description/technique by some. The most effective technique in a given aerial combat situation must be an individual decision. We have simply found this "Hook" maneuver method to be an extremely effective teaching tool. One that is easily understood, rapidly mastered, and easily remembered by fighter-attack aviators. It is very useful when trying to coach an aviator who is having trouble during a short 10 to 15 second centrifuge training run. The instructor has merely to suggest "Say Hook!" to the trainee. A large number of veteran USMC, USAF, and USN aviators have strongly praised the technique.

Table 1. Sequence Of Performing, The "Hook" Maneuver.

A. Muscular Component

Maximum tensing of all skeletal muscles.

B. Respiratory Component

1. Rapid, deep inspiration
2. Forcefully initiate exhalation by saying "Hook" and holding it 3/4 of the way through the word "HOOO. . . "

DURATION 2.5-3.0 sec.

3. Completely close glottis
4. Maximum abdominal and chest muscle tensing
5. Rapid, forceful exhalation - finish the work "HOOK" by blowing out "KA . . ."

DURATION 0.5-1.0 sec.

REPEAT SEQUENCE

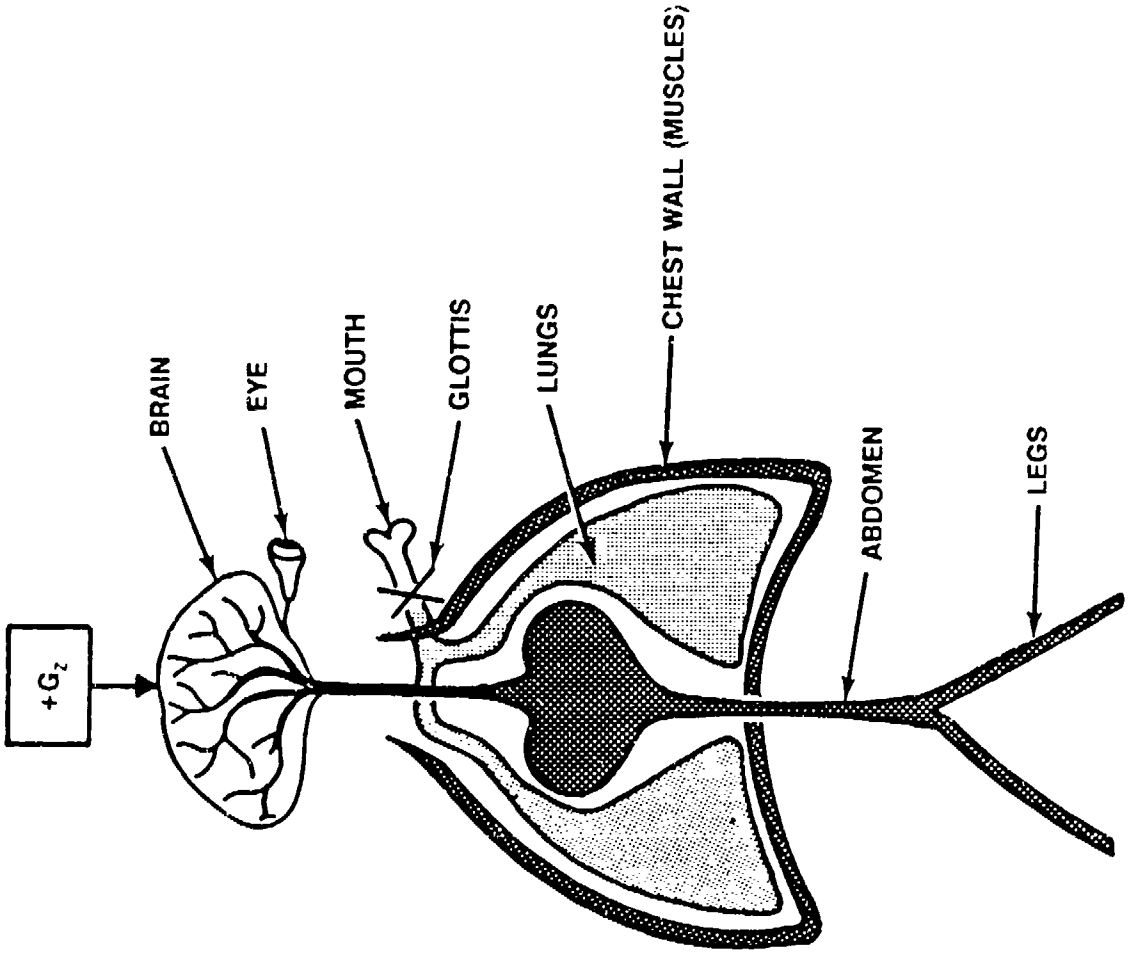

Figure 1. Schematic Of The Respiratory Tract. Note The Location For Optimum Closure OF The Respiratory Tract At The Glottis.

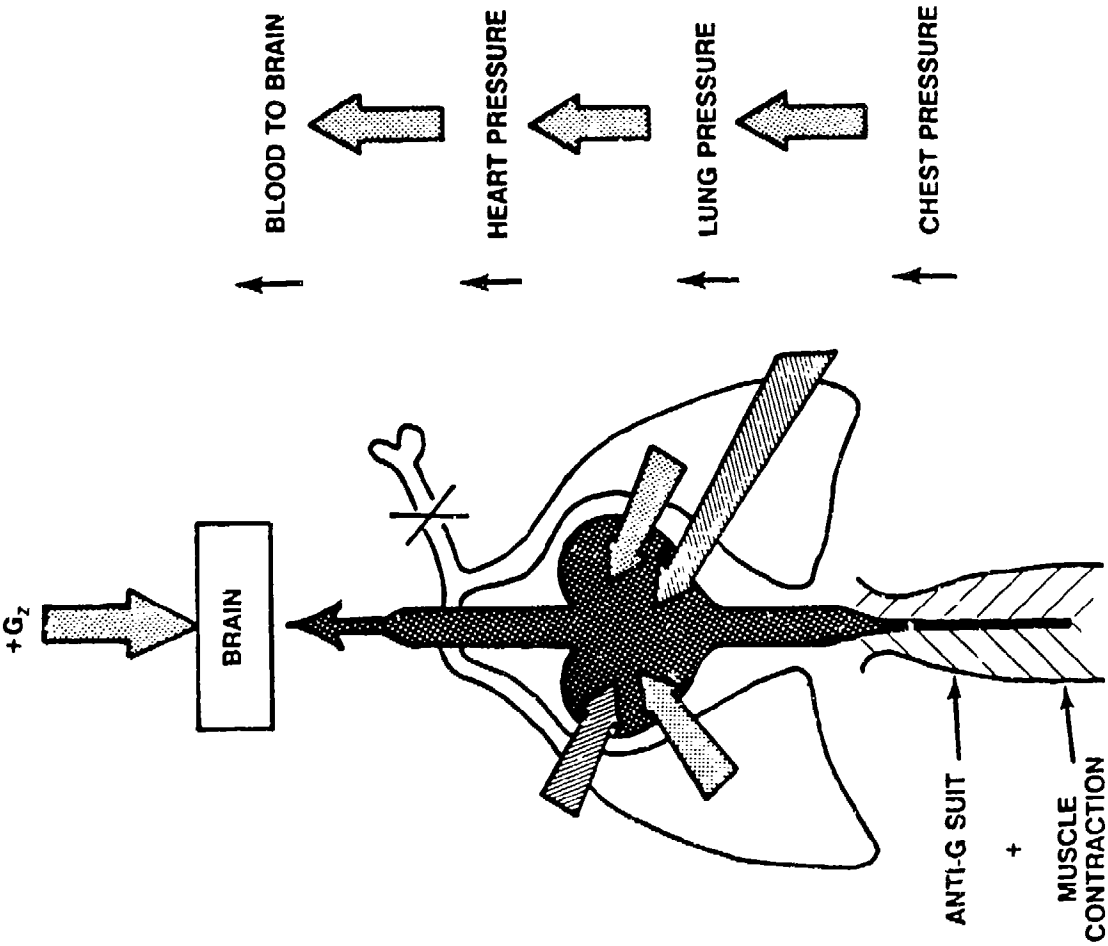

Figure 2. Physiological Mechanics Of Increasing Tolerance To $+G_z$ With The Anti-G Straining Maneuver.

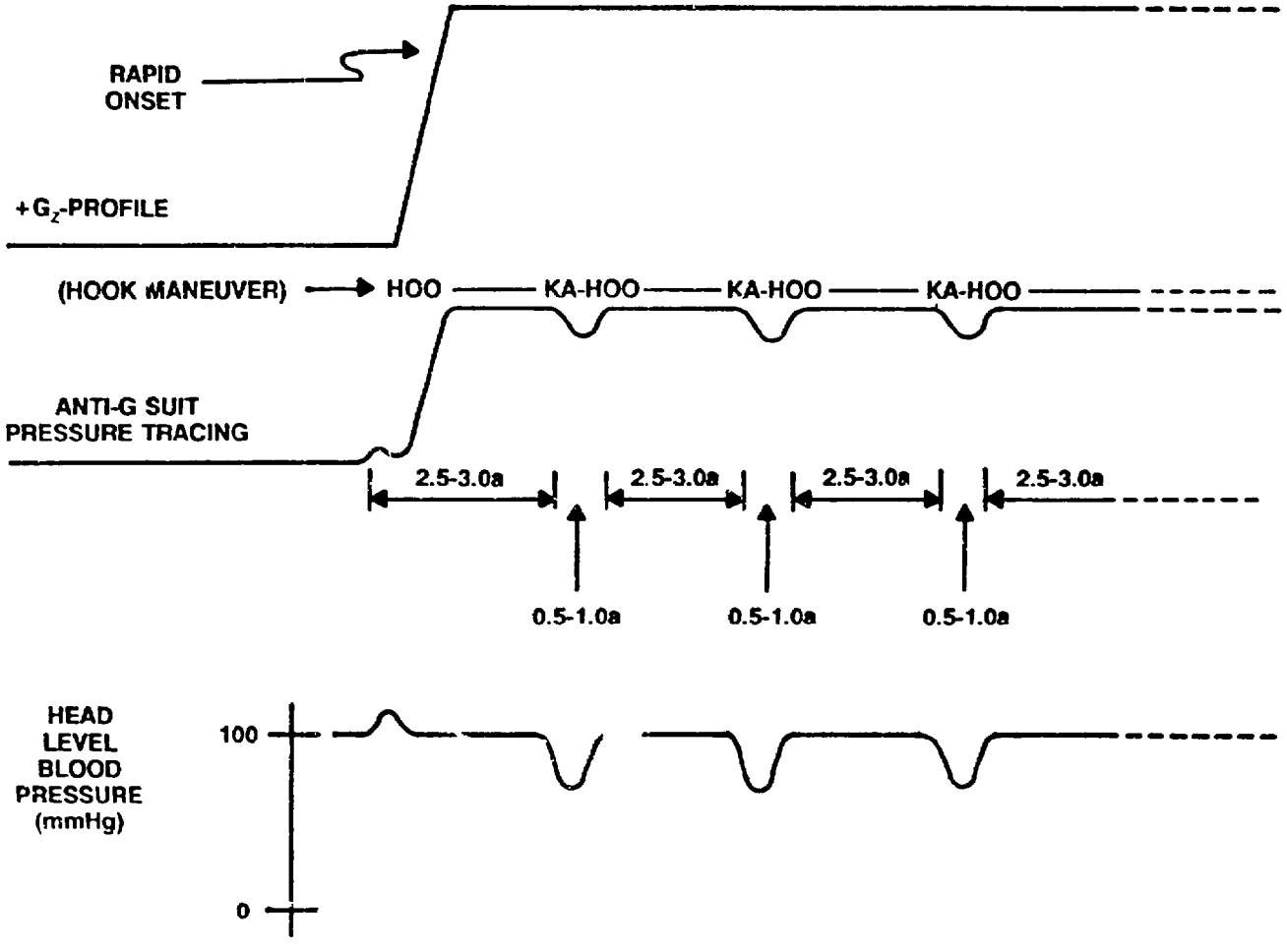

Figure 3. Rapid onset $+G_z$ Exposure Profile With Performance Of The "Hook" Maneuver. The Timing Of The Respiratory Component And The Resulting (Example) Head Level Blood Pressure (mmHg) Are Also Shown.

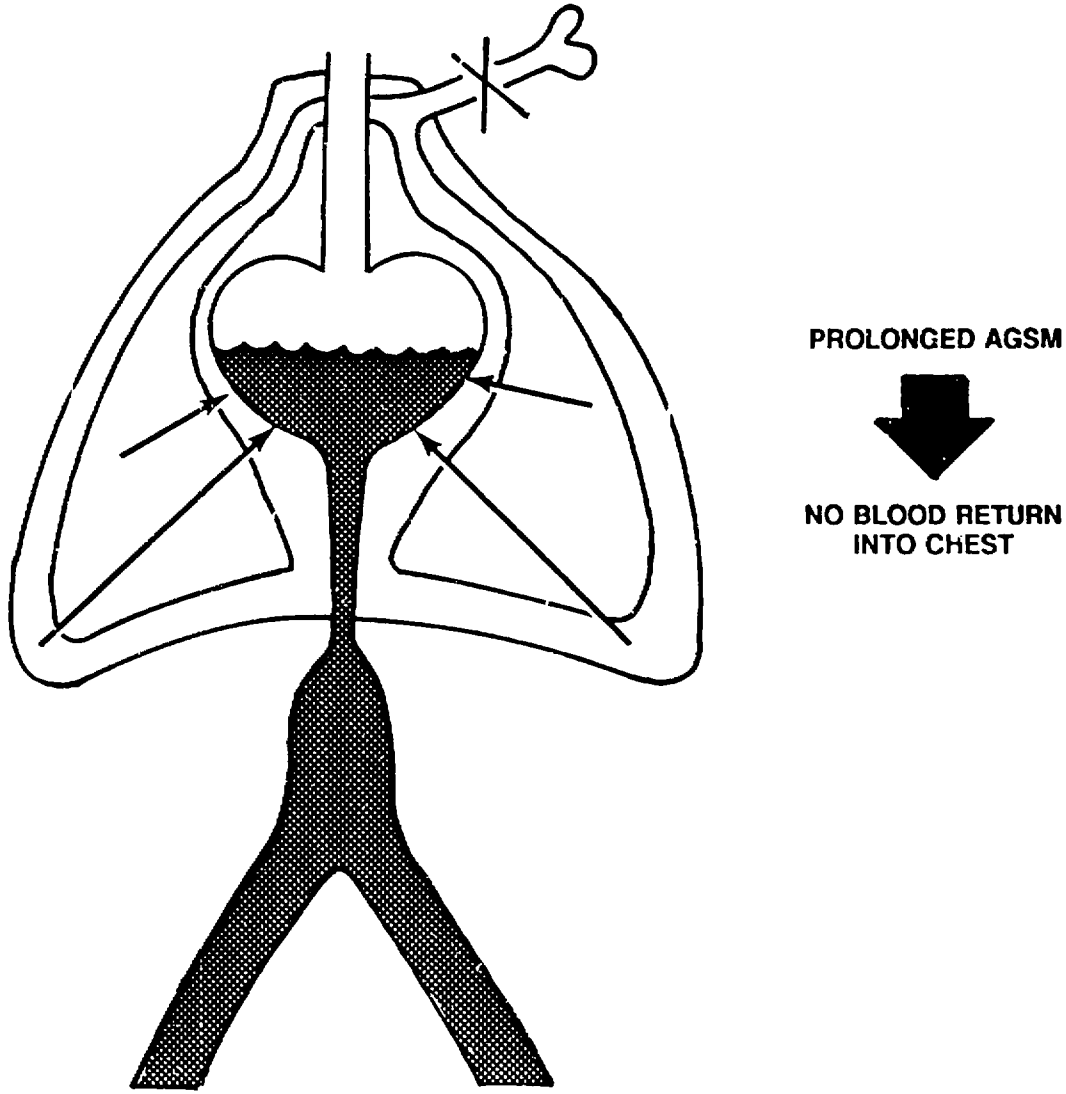

Figure 4. The Resulting Consequences Of Holding The Respiratory Component Of The Anti-G Straining Maneuver Too Long, Which Causes A Prolonged Loss Of Return Of Blood Flow To The Chest (Heart).

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